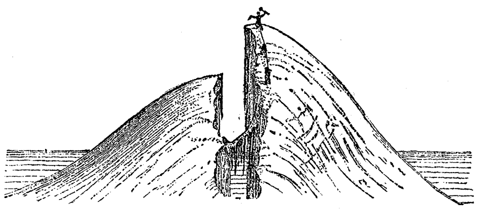
of the ridge, the neighboring peaks rose around them; and all New Zealand, from western to eastern coast, with the ocean beyond on either side, lay below. The



THE TOP OF MOUNT HOCHSTETTER.

story of the journey is simply and graphically told, and suggests a writer of more intelligence and better powers of observation than is usually met with among mountain climbers.

THE DIGESTIBILITY OF CELLULOSE.

IT is a well-established fact, that a considerable portion of the woody fibre which is consumed in such large amounts by herbivorous animals does not re-appear in their excrements, but is apparently digested. In what portion of the alimentary canal, or by means of what secretion, this digestion is accomplished, has been the subject of much speculation and of some experiments; but, until recently, neither had done much to illuminate the matter.

Hofmeister [1] seemed to have gone far towards solving the question when he found that a considerable solution of the cellulose of grass took place in the rumen of sheep. He first enclosed two small samples of fresh grass in cages of german-silver wire covered with muslin, and introduced them into the rumen of a living sheep. After three days the animal was killed, the cages removed, and their contents examined. It was found that seventy-eight and four-tenths per cent of the woody fibre originally present had been dissolved. Subsequent experiments showed that the fluid obtained from the rumen of a freshly killed sheep had also a powerful solvent action on woody fibre, and that the mixed saliva had likewise this power. Experiments on oxen gave no decisive result: those on the horse failed to show any solvent action of the saliva upon woody fibre. Hay, and the 'crude fibre' prepared in the analysis of fodders, were acted upon by the fluid from sheep's rumen, though not so energetically as was the grass.

These results point unmistakably to the first stomach of ruminants as one place where cellulose is digested. Hofmeister ascribes to the mixed saliva the power of dissolving it; but some subsequent experiments by Tappeiner [2] indicate that this is effected by a fermentative process, and that the saliva or fluid from the rumen used by Hofmeister served simply to supply food to the organisms concerned in the fermentation. Tappeiner took samples of the contents of rumen, small intestine, and large intestine, of a ruminant fed exclusively on hay. One sample from each portion of the alimentary canal was at once boiled; to a second some antiseptic (chloroform, thymol) was added, sufficient to stop the action of organized ferments; while to the third nothing was added. All were kept warm, and after a time their content of crude fibre was determined. Those portions from the rumen and large intestine, to which nothing was added, were found to have lost cellulose, while carbonic acid and marsh-gas were evolved. No loss was observed from the contents of the small intestines, nor from the samples treated with antiseptics. Further experiments showed that this fermentation could be produced outside the body. To hay or pure cellulose, mixed with extract of meat, and previously heated to 110° C., a drop of fluid from the rumen was added. After a few days, active fermentation began. Gas was freely evolved, consisting of about seventy-six per cent of carbonic acid and twenty-four per cent of marsh-gas, and the cellulose nearly all disappeared. A second kind of fermentation was also observed, which yielded carbonic acid and hydrogen. In both kinds of fermentation, only the smaller part of the cellulose was volatilized, most of it being converted into acids of the fatty series.

That cellulose is fermentable is not a new observation; Van Tieghem having found that the butyric ferment has the power of decomposing it, with production of hydrogen, carbonic acid, and butyric acid. Tappeiner's experiments are of interest, because they show that the fermentation takes place also in the alimentary canal. This is shown not only by the disappearance of the cellulose in the experiments described above, but also by the presence of the products of the fermentation in stomach and intestines. In ruminants the marsh-gas fermentation seems to prevail. In the stomach of the horse and swine considerable quantities of hydrogen were found. In both cases acetic acid, aldehyde, and an acid having the composition of butyric acid, were found.

These results are important in their bearing on our estimates of the nutritive value of fodders. It having been shown that the digestible portion of the crude fibre has the composition of starch, it has generally been assumed to have the same nutritive value. Tappeiner's experiments show that this is probably not the case. There appears to be a disposition on the part of some critics, however, to rush to the opposite extreme, and, instead of overestimating the nutritive value of cellulose, to underestimate it. The non-nitrogenous nutrients are to be regarded as the fuel of the body, and they are of worth to it in proportion to the amount of energy set free by their oxidation to carbonic acid and water. So far as we can see, it is a matter of indifference whether that oxidation begins in the alimentary canal, or not until the substance has passed into the circulation. Whatever potential energy is contained in the digested cellulose is yielded up to the body sooner or later, with the exception of that portion which escapes in the form of combustible gases. According to Tappeiner, this

[1] *Biedermann's centralblatt*, Jahrg. x. p. 669.

[2] *Thier. chem. ber.*, xi. 303, xii. 266 and 272; *Zeitschr. für biologie*, xx. 52.

portion is small. Since, now, the heat of combustion of cellulose is the same as that of starch, according to von Rechenberg's determinations,[1] the difference in the nutritive value of the two must be measured by the heat of combustion of the marsh-gas and hydrogen evolved.

The well-known experiments of Henneberg and Stohmann on the respiration of sheep showed no considerable excretion of either hydrogen or marsh-gas. In one of them, for example, the animal ate per day 1,216 grams of hay, and excreted 1.5 grams of marsh-gas. Not having at hand the original account of the experiment, we will assume that the hay contained only twenty-five per cent of crude fibre, of which one-half was digested. This amounts to 152 grams per day. This quantity of cellulose, if oxidized to carbonic acid and water, would yield 676,704 cal.[2] From this we have to deduct the amount of heat carried off in 1.5 grams of marsh-gas, which, according to Favre and Silbermann, amounts to 19,595 cal. There remain 657,109 cal., representing the worth of the 152 grams of cellulose to the animal. The same weight of starch, if completely oxidized, would yield 680,808 cal.: in other words, the cellulose set free in the body of the animal ninety-six and a half per cent of the energy which the same weight of starch would have done.

Naturally these calculations are not exact; but they serve to show, that, if the heat liberated during the fermentation of the cellulose is of use to the animal, the nutritive value of cellulose does not fall so much below that of other carbohydrates as some are inclined to believe.

H. P. ARMSBY.

IS THE RAINFALL OF KANSAS INCREASING?[3]

THIRTY years ago the territory of Kansas was not occupied by the white man, and, if we except a few acres cultivated by the Delaware Indians, no portion of her soil had been turned up by the plough. Her entire area was included within the vast and almost unknown region of the 'treeless plains' and the 'great American desert.' During that brief intervening period, more than a million people, chiefly of the agricultural class, have taken possession of her domain, and have already brought her to the very front rank of the states of the Union in the extent and value of her agricultural products. History affords no other instance of the permanent occupation of so extensive an area, previously unoccupied by man, by so large an agricultural population, in so short a space of time. Here, certainly, if human agency could anywhere affect climate, would such an effect be produced. Here, assuredly, if settlement ever increases rainfall, will such increase be most marked and most unmistakable. That such increase has actually taken place, I believe to be established beyond a doubt. It is a circumstance peculiarly favorable to the determination of the point in question, that, although the general settlement of Kansas by cultivators of the soil is of such recent date, reliable observations upon the rainfall had been made at the military posts upon the eastern borders for a sufficient period to make possible a satisfactory comparison between the rainfall before settlement and after settlement. The records at Fort Leavenworth cover the longest period, and enable us to compare the nineteen years immediately preceding the occupation of Kansas by white settlers with the nineteen years immediately following such occupation. During the first period the average rainfall was 30.96 inches; during the second period it was 36.21 inches; giving an average increase of 5.21 inches per annum, — an increase of nearly twenty per cent. The Fort Leavenworth records cover so long a period of time (nearly forty years), that the increased average of the second half of the period cannot be attributed to a mere 'accidental variation.' In the issue of *Science* for April 18, 1884, it is stated that "the supposed increase in the rainfall in the dry region beyond the Mississippi is not borne out by the returns of the signal-service." But the records of the signal-service upon which this statement was based include a period of only twelve years of observation (from 1871 to 1882), which is undoubtedly too short a period for either establishing or disproving the fact of a 'secular' variation.

But the fact of an increased Kansas rainfall does not rest entirely upon the Fort Leavenworth observations. There are other stations in Kansas whose records cover a much longer period than that of the longest established regular station of the signal-service. There are the twenty years' records of the U. S. military post at Fort Riley, the twenty-four years' records of the State agricultural college at Manhattan, and the seventeen years' records of the State university at Lawrence. If these several periods of observation be divided into two equal parts, in each case it is found that the average rainfall of the second half is notably greater than that of the first half. At Fort Riley the increase amounts to 3.05 inches per annum, and at Manhattan to 5.61 inches per annum, and at Lawrence to 3.06 inches per annum. Expressed in per cent, the rainfall of these three stations has increased in the second half of each period of observation, at Fort Riley, thirteen per cent; at Manhattan, twenty per cent; and at Lawrence, over nine per cent. If the increased rainfall could be shown by the records of a single station only, or if the several stations with sufficiently long periods of observation exhibited discordant results (some indicating a decrease, while others indicate an increase), or if even a single station indicated a diminished rainfall, the fact of a general increase would lack satisfactory demonstration. But the entire agreement of the four stations whose records have been used in a discussion of this question seems to establish beyond doubt the fact of an increased rainfall in the eastern half of Kansas.

There can be no reasonable doubt that the general

[1] *Journ. prakt. chem.*, n. f., xxii. 1 and 223.

[2] 1 cal. = the amount of heat required to raise the temperature of 1 gram of water 1° C.

[3] Lecture before the Kansas academy of sciences, Nov. 25, by Prof. F. H. SNOW.